pensating advantages over the alternatives of municipal ownership and direct municipal operation or regulation by a commission remains to be demonstrated. The chief significance of the arrangement lies in the evidence it affords of the failure of the policy of control through limited franchises.

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PROGRESS OF THE AUTOMATIC LOOM

Among the recent inventions of cotton-mill machinery none is more significant than the automatic loom. In spite of the scepticism still shown in certain quarters, the day for the general acceptance of some type of automatic loom for weaving cotton cloth appears to be close at hand. An automatic loom, it may be explained, is one in which the shuttle, which carries the weft or thread crosswise of the cloth, is either automatically replenished or automatically replaced, without assistance from the weaver or stoppage of the machine. It thus becomes possible for a loom, barring accidents, to run continuously, instead of being brought to a standstill each time the thread on the bobbin in the shuttle is exhausted. In the ordinary loom, a fresh bobbin must be supplied every seven or eight minutes; hence stops are frequent. In the following paragraphs the recent progress of automatic looms is outlined and points of interest to economists are indicated.

The history of automatic looms centers around the Northrop invention developed by the Draper Company of Hopedale, Massachusetts. The Northrop loom, as offered to the trade in 1894, was the result of the efforts of five inventors, deliberately applied for fifteen years to the task of rendering practical the ideas brought to this country by Northrop. It has been described in a previous article;[1] hence it is not

[1] M. T. Copeland, Technical Development in Cotton Manufacturing since 1860, Quarterly Journal of Economics, November, 1909.

necessary to repeat the details. Suffice it to say that by January 1, 1911, approximately 200,000 Northrop looms had been installed in over three hundred American cotton mills[1] and several thousand in European mills. One other American automatic loom has secured acceptance on a limited scale; still others are on trial.

In Europe the appearance of the Northrop machine has roused widespread interest, but its high price has caused many manufacturers to seek a cheaper substitute. The extensiveness of these researches is indicated by the fact that during the past year no less than eight types of automatic looms, all of domestic manufacture, have been seen by the writer in European cotton mills.[2] This probably does not exhaust the list, since several of the looms were in use only by the manufacturers who had invented them, and it is reasonable to suppose that other experiments are being carried on semi-secretly in mills not visited. It seems to be the consensus of opinion that the Northrop loom is the best, altho a few of its competitors are said to possess certain points of superiority.[3]

All these looms, however, are suitable for weaving only plain cloth and fabrics with stripes or figures formed by manipulation of the warp threads. It has been a more serious problem to devise a means for automatically supplying weft to a drop-box loom, which uses filling of several colors. A drop-box loom has two or more shuttle boxes, according to the number of colors of weft yarn. The boxes are placed vertically, one above the other, and their movement is made to conform to the details of the pattern which is being woven.

[1] Data furnished by the Draper Company.

[2] Three were English, three German, and two French. Still another automatic loom, of Swiss origin, is mentioned by Mr. Besso, Cotton Industry in Switzerland and Italy, p. 38.

[3] The machine brought out two years ago by the Elsässische Maschinenbau Gesellschaft, Mülhausen, for example, has a new form of magazine from which the shuttle is filled. It is so placed at the end of the loom that it does not obstruct the weaver's view. Moreover, it is detachable so that it can be taken off to be mechanically refilled by a boy or girl. The weaver is thus relieved of all work even in replenishing the magazine and can tend more looms.

The best known cloths woven upon drop-box looms are checks and ginghams. Some of these fabrics have very narrow weft stripes; hence the failure to change shuttles at exactly the proper moment, the passage of an empty shuttle, or the insertion of a thread of the wrong color would produce a noticeable and serious fault. These stringent requirements and the multiplicity of shuttle boxes were obstacles in the path of an automatic drop-box loom. Nevertheless, the difficulties have been overcome.

In 1895, immediately after the appearance of the Northrop loom, Crompton and Knowles, loom manufacturers of Worcester, Massachusetts, began to experiment with automatic gingham looms. The first patent was taken out by Charles Crompton and Horace Wyman, and in 1905 a few such machines were placed in operation. During the following five years continual refinement and alteration materially improved this loom, which is adapted to the use of "filling of different colors inserted at predetermined intervals, and equipped with the necessary detector and safety devices to admit of weaving practically perfect goods."[1]

The first examples of these automatic drop-box looms were equipped with circular revolving magazines, from which the bobbins were supplied to the shuttles and in which the bobbins were arranged in such an order that the machines always took yarn of the proper color. This form of magazine has been discarded, however, in favor of a vertical stationary magazine provided with a separate section for each color of weft yarn. Similarly, the original electrical detector has been largely supplanted by a mechanical detector which feels the amount of thread on the bobbin at each passage of the shuttle. When the bobbin is nearly depleted another of the same color is automatically selected from the magazine. Yet it cannot always be immediately introduced into the shuttle, since the pattern may demand the shuttle from another box for the next pick. Consequently the selected bobbin is held in suspense until the shuttle for which it is intended again comes into action. The parts work in

[1] Quoted from a circular issued by the company.

unison, so that a fresh bobbin cannot be placed in the wrong shuttle. Several of the patents of the Northrop loom were utilized for the new gingham loom, and great credit is due to that pioneer work. On the other hand, the conquering of the difficulties peculiar to an automatic drop-box loom is an achievement of the first order.

The automatic gingham loom runs at least as fast as the ordinary loom employed for similar work, namely, 165 picks per minute, and occasionally exceeds that speed by five picks per minute. Therefore there is no loss in that direction. Moreover, the automatic loom is more constantly in operation, inasmuch as it does not stop each time a bobbin is empty. Thus there is a closer approach to the highest possible productivity. Of even more importance, particularly to American manufacturers, is the reduction in the amount of attendance required. In this country a weaver usually tends six ordinary drop-box looms. With the automatic loom the number is at least doubled and in some instances reaches sixteen per weaver. Altho a recent innovation, one mill already has two thousand of the new looms at work and several other manufacturers have ventured to try them.

With the introduction of the Crompton and Knowles loom, one may prophesy that eventually all types of loom employed in cotton mills will be provided with automatic weft-changing devices. The history of the power loom in the nineteenth century is being repeated by the automatic loom in the twentieth century.

For the economist the history of the automatic loom illustrates several principles. In the first place it shows the efforts to relieve pressure at the point in a cotton mill where the expense for labor has been highest. The readjustment of piece rates has reduced by one half the labor cost of weaving. The improvements in the mule, the ring frame, and the preparatory machines had already cut down the expense for labor in those departments, thus making the outlay for labor in the weaving department more conspicuous, until that too was diminished by the automatic loom. In the

second place, the flexibility of demand and the limits to monopoly power are indicated by the attempts to find a substitute for the Northrop loom. The ownership of the Northrop patents brings about a monopoly and the price of the machine is high.[1] Hence the European manufacturers are seeking a less expensive substitute. Thirdly, the use of the automatic loom will very likely cause greater standardization and specialization in weaving mills, since it is not economically advantageous to employ a weaver upon looms weaving several patterns. Hitherto, in fact, the introduction of the Northrop loom into Europe has been retarded by the practice among the European manufacturers of accepting so many relatively small orders that it is frequently impossible to avoid employing one Northrop loom weaver upon fabrics of several designs. The advantages attendant upon a more extensive use of the automatic loom, therefore, will foster standardization and specialization. Finally, the history of automatic looms tends to disprove the theory that inventions are sporadic products. All the advances in automatic looms have been the results of prolonged efforts consciously directed toward a specific end. The possibility of automatic looms had been broached prior to 1880, but it was not till the need became acute that the task was undertaken in an effective manner. That these contributions have been made by Americans is largely due to the greater premium which our higher wages have placed upon labor-saving devices.

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[1] This statement does not necessarily imply that the price is higher than is warranted by the expense and risk of the long period of experimentation.